INDOOR AIR QUALITY ASSESSMENT

Oliver Wendell Holmes Elementary School
40 School Street
Boston, Massachusetts 02124

Prepared by:
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Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program

May 2004

Background/Introduction

At the request of several teachers, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Oliver Wendell Holmes Elementary School (HES), located in the Dorchester neighborhood of Boston, Massachusetts. The request was prompted by cancer and indoor air quality concerns.

On June 20, 2003, a visit to conduct an indoor air quality assessment was made to the HES by Michael Feeney, Director of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Feeney was accompanied by the following BEHA staff: Sharon Lee, Environmental Analyst, ER/IAQ Program, Danielle Hoffman, Epidemiologist, Environmental Epidemiology Program and Cathy Brown, Senior Risk Communicator, Community Assessment Program. BEHA staff were also accompanied by Jeffrey Lane, Environmental Specialist, Boston Public Schools (BPS).

The HES is a two-story brick building constructed in 1905. The HES operated for a number of years then closed. Renovations to the building were made during the late 1980s into the early 1990s. The school was reopened in 1991. The basement consists of general classrooms and a band room. The first floor is comprised of general classrooms, nurse's office, cafeteria, kitchen, teachers' room, art room, activity room, and office space. General classrooms, as well as a computer room and library are located on the second and third floors. Windows throughout the building are openable.

Previous inspections were conducted at the HES by the Boston Public Health Commission (BPHC) from December 2002 – February 2003. The inspections were primarily concerned with conditions of basement level rooms following a flooding incident. On their December 9, 2002 visit, BPHC officials observed standing water in the basement level music room and the adjacent boiler room. As a result of the water infiltration, cardboard boxes and carpeting became water damaged. The source of water infiltration was not identified however, the BPHC made the following recommendations:

- Repair leaking pipes;
- Remove all water damaged material, including cardboard and rugs;
- Operate heating to ensure occupant comfort;
- Repair emergency door to ensure function; and
- Remove items blocking exhaust vents. (BPHC, 2003)

On subsequent reassessments, the BPHC noted water damaged cardboard and standing water had been removed from the music room. Standing water, however, remained in the boiler room.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The HES services approximately 400 students in grades K–6, and has a staff of approximately 40. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation Concerns

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million of air (ppm) in 12 of 28 areas surveyed, indicating inadequate air exchange in a number of areas of the school at the time of the assessment. Please note that many of the classroom windows were open during the assessment. Open windows can greatly reduce carbon dioxide levels. With windows closed during the heating season, carbon dioxide levels would be expected to increase.

The HES was originally equipped with a mechanical ventilation system, which is currently abandoned. Fresh air from this system was provided by two large fans, which are located in basement fan rooms (Picture 1). Between each fan room is a smaller room that houses the motor. In this type of system, fan belts connect the fan flywheels to the motor for mechanical operation (Pictures 2a and 2b). Fresh air would be drawn into each fan room through exterior vents, located at the front of the building (Picture 3). Air would then be drawn through heating elements in each fan room. Ductwork connecting the fans to the wall mounted fresh air diffusers facilitated the distribution of fresh air to classrooms (Picture 4).

As previously discussed, the mechanical ventilation system is currently abandoned. It appears that the fan belts were severed and the fan belt motor was deactivated. The ventilation system was likely abandoned either as part of an earlier energy conservation project or during the renovations of the 1980s.

The exhaust system appears to depend on air pressurization. Air pressurization forces classroom air towards the exhaust vent. As air is exhausted it exits the building through louvered vents located on the roof (Pictures 5a and 5b). Some of the louvers were closed. Without the operation of the fresh air supply system, exhaust ventilation from classrooms is minimized. Exhaust ventilation is further hindered through blockages of exhaust vents by boxes or furniture (Picture 6). Without pressurization, exhaust vents on the roof may allow for cold air to backdraft into classrooms under certain wind and weather conditions.

Currently, openable windows are the only means for introducing airflow into building. The HES was configured in a manner to use cross-ventilation to provide comfort for building occupants. The building is equipped with windows on opposing exterior walls. This design allows airflow to enter an open window, pass through a classroom and subsequently pass through open classroom doors. Airflow then enters the hallway, passing through the opposing open classroom door, into the opposing classroom and finally exits the building on the leeward side (opposite the windward side) (Figure 1). With all windows and hallway doors open, airflow can be maintained in a building regardless of the direction of the wind. This system fails if the windows or doors are closed (Figure 2). Rooms that are not opposite other classrooms would have increased difficulty in creating cross ventilation and would need some means to increase air movement (e.g., floor fan in an open window). In order to facilitate airflow, hallway doors should be opened. Rooms are heated using wall-mounted radiators.

Classrooms on the basement floor were created through the subdivision of a larger space. Basement classroom 002 was retrofitted with a unit ventilator (univent) system (Picture 7). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (Figure 3). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located on the top of the unit. The univent was deactivated during the assessment. In order for univents to provide fresh air as designed, units must be allowed to operate while rooms are occupied. Air diffusers and return vents must also remain free of obstructions [Picture 8 shows material (i.e., cigarette stub) in the diffuser]. Lastly, no means for mechanical exhaust ventilation could be identified in this area.

Some occupied spaces in the basement do not appear to have directly ducted sources of fresh air supply. Rooms adjacent to room 002 had passive vents on walls to allow air to pass from room 002's univent. Other rooms on all floors had neither fresh air supply nor exhaust ventilation. With windows closed and no means for mechanical supply and exhaust ventilation, indoor air pollutants can build up and lead to indoor air quality/comfort complaints.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The mechanical ventilation system, in its current condition, cannot be balanced.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 ppm. Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, consult Appendix A.

Temperature measurements ranged from 70° F to 78° F, which were within the BEHA recommended comfort range in all areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Often times, temperature control is difficult, especially in an old building lacking an operational mechanical ventilation system.

The relative humidity measured in the building ranged from 45 to 62 percent, which was close to the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. It is important to note that relative humidity measured indoors exceeded outdoor measurements by 14 to 31 percent. This increase in relative humidity can indicate that natural ventilation alone may not be sufficient in removing normal indoor air pollutants (e.g., water vapor from respiration). Moisture removal is important, since the sensation of heat conditions increases as relative humidity increases.

The relationship between temperature and relative humidity is known as the heat index. As indoor temperature rises, the addition of relative humidity will make occupants increase occupant discomfort and generate heat complaints. If moisture levels are decreased, the comfort of the individuals increases. Removal of moisture from the air, however, can have some negative effects. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

As previously mentioned, a pipe leak resulted in water damage to basement classrooms. BPS and BPHC staff addressed a number of the problems stemming from the pipe leak; however, a number of additional issues were observed. Water damaged insulation was noted on pipes in the music room (Picture 9). Water damaged insulation can provide a source for microbial growth and, therefore, should be removed.

The basement wall of the music room also had signs of water damage. This was evidenced by the presence of peeling paint and efflorescence along exterior brick walls (Picture 10). Efflorescence appears as a white, chalky residue and is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar around brick, water-soluble compounds in bricks and mortar dissolve, creating a solution. As the solution moves to the surface of the brick or mortar, the water evaporates, leaving behind white, powdery mineral deposits. A coat of paint can serve as a water impermeable barrier, which can trap moisture. While brick and mortar are not viable sources for mold growth, water trapped in spaces between the paint and brick can become mold growth media.

Water damage was noted on plaster ceilings in many parts of the school. In room 204, water damage on the ceiling was noted around a pipe (Picture 11). Water damage also occurred to windowsills in the main hallway. As with brick and mortar, ceiling plaster does not provide a source for mold growth, however, water trapped in paint layers does.

Standing water was noted in a parapet adjacent to the second floor gymnasium walkway (Picture 12). Standing water can provide a source for microbial growth and odor production. Pooling water against the building exterior can result in damage to the exterior. Over time, interior portions of the building can also sustain damage.

Water coolers are located in a number of hallway areas. Standing water and debris were noted in catch basins (Picture 13). Stagnant water was also observed in a pan located near a window. As previously discussed, stagnant water can provide a medium for bacterial and microbial growth. To prevent growth, catch basins and pans should be emptied and cleaned regularly.

Plants were located on windowsills in several classrooms and hallways (Picture 14). Some plants were found on top of univents, while a container filled with dry soil was found atop another univent. Plants, soil and drip pans can serve as sources of mold growth, thus should be properly maintained. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should also be located away from univents and ventilation sources to prevent aerosolization of dirt, pollen or mold.

A number of other conditions observed along the building exterior may be conducive to water penetration through the building envelope. One wall in the school courtyard had substantial clinging plant growth (Picture 15). Clinging plants can cause damage to brickwork through the insertion of tendrils into brick and mortar. Water can penetrate into the brick along the tendrils, which can subsequently freeze and thaw during the winter. This freezing/thawing action can weaken bricks and mortar, resulting in damage. This type of plant growth on brickwork is not recommended.

Shrubbery and other plants were also observed to be growing in cracks and crevices in close proximity to the foundation walls. The growth of roots against the exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek

& Brennan, 2001). Lastly, moss was observed to be growing on exterior windowsills. Moss growth is an indication of water accumulation, which can result in damage to building materials.

Other Concerns

The abandoned ventilation system can serve as a pathway for basement particulates and odors to migrate into classrooms and other occupied areas of the HES. In general, cold air migrates to areas with heated air, thereby creating drafts. The temperature in the basement and fan rooms will generally be lower than that of occupied areas, therefore colder basement air will move to classrooms if breaches and exit points exist. A number of different source pathways allow for basement air, odor and particulates to enter the ventilation system. The entrance to the fan motor room has no door. Louvers as well as the doors to the fan rooms are also open (Picture 16). These openings allow basement air, odors and particulate matter to become entrained into the vent system and migrate into occupied areas.

Similarly, spaces were noted around pipes in the music room (Picture 9). Since these pipes lead to the boiler room, spaces around these pipes allow for the introduction of boiler odors and particles into the music room

Accumulated chalk dust was noted in some classrooms (Picture 17). Chalk dust is a fine particulate that can easily become aerosolized, irritating eyes and the respiratory system. Similarly, pencil shavings were observed to be accumulating at the base of pencil sharpeners (Picture 18). In many classrooms, pencil sharpeners are stationed on bookcases located in front of windows. When windows are opened, pencil shavings can become airborne, providing a source for eye and respiratory irritation.

A number of classrooms contained upholstered furniture (Picture 17). Upholstered furniture is covered with fabric that comes in contact with human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. Furthermore, increased relative humidity levels above 60 percent can also perpetuate dust mite proliferation (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, 1994). It is also recommended that upholstered furniture present in schools be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000), since particulate can enter the building through open windows, doors and the ventilation system.

Several classrooms contained dry erase boards and dry erase board markers. An uncapped permanent marker was also observed in one classroom (Picture 19). Materials such as dry erase marker, dry erase board cleaners and permanent markers may contain volatile organic compounds (VOCs), such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

In an effort to reduce noise from sliding chairs, staff cut open tennis balls placed them on chair legs (Picture 20). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Photocopiers were located in an area outside of the nurse's office. At least one printer (Risograph®) uses a liquid toner. Photocopiers also produce VOCs. In addition, photocopiers produce ozone and excess heat, particularly if the equipment is older and in frequent use. VOCs and ozone are respiratory irritants (Schmidt Etkin, 1992).

Of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were seen on windowsills, tabletops, counters, bookcases and desks. The large amount of items stored in classrooms provides a means for dusts, dirt and other potential respiratory irritants to accumulate. Many of the items, (e.g. papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. These items should be relocated and/or cleaned periodically to avoid excessive dust build up.

Cleaning products and other chemicals were found in floor level cabinets and on countertops in several classrooms. Activated carbon was found in a cabinet under a sink in the photocopying area. Cleaning products contain chemicals, such as bleach or ammonia-related compounds, which can be irritating to the eyes, nose and throat.

A number of pest attractants were identified within or around the building. In the fan room, rock salt was stored in flour sacks (Picture 21). A drainpipe in an exterior retaining wall was blocked with a soda can. Food containers were also used for storage. Reuse of former food containers in this manner can be a pest attractant since food residue is likely present in containers despite cleaning efforts. To decrease the attraction of pests, such reuse of food containers is not recommended.

According to BPS officials, the HES has a history of rodent problems. Rodent infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine contains a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms (e.g., running nose or skin rashes) in sensitive individuals. Since particulate materials can be drawn into an air stream, univents with filters that provide minimal respirable dust filtration can serve to distribute these materials. It is important that proper filters be installed in univents to reduce this potential problem.

A three-step approach is necessary to eliminate rodent infestation:

- removal of the rodents;
- cleaning of waste products from the interior of the building; and
- reduction/elimination of pathways/food sources that are attracting rodents.

To eliminate exposure to allergens, rodents must be removed from the building. Please note that removal, even after cleaning, may not provide immediate relief since allergens can exist in the interior for several months after rodents are eliminated (Burge, 1995). Once the infestation is eliminated, a combination of cleaning and increased ventilation and filtration should serve to reduce allergens associated with rodents. In efforts to eliminate pest problems, baited traps were placed in a number of classrooms.

Health Concerns

In June 2003 staff from the Community Assessment Program (CAP), a division within the Bureau of Environmental Health Assessment (BEHA), accompanied staff from the BEHA's Emergency Response/Indoor Air Quality Program (ER/IAQ) on an inspection of the Oliver Wendell Holmes Elementary School. In addition to concerns about the air quality at the school, staff also had concerns about a suspected increase of cancer incidence among employees of the Holmes School. In order to further investigate these concerns, CAP staff instructed employees of the Holmes School at the time of the ER/IAQ inspection to submit a written request to the BEHA that contained information on each individual diagnosed with cancer including primary site of cancer, approximate age and date of diagnosis, and approximate dates of employment at the Holmes School.

In September 2003 the BEHA received a written request from a staff member of the Holmes Elementary School that contained a list of 4 current and former employees of the school who had reported a diagnosis of cancer. In addition, it was also reported in the request that a former employee of the Holmes School had passed away. However, the staff member submitting the request indicated that this individual had died of an unknown cause. No additional information on this employee (i.e., name) was included in the request.

In response to this request, CAP staff reviewed the most recent data available from the Massachusetts Cancer Registry (MCR) to confirm cancer diagnoses reported among staff at the Holmes School and to determine whether these diagnoses may represent an unusual pattern of cancer incidence. The MCR, a division within the MDPH Center for Health Information, Statistics, Research and Evaluation, is a population based surveillance system that has been monitoring cancer incidence in the Commonwealth since 1982. All new diagnoses of cancer among Massachusetts residents are required by law to be reported to the MCR within six months of the date of diagnosis (M.G.L. c.111. s 111b). This information is kept in a confidential database. Data are collected on a daily basis and are reviewed for accuracy and completeness on an annual basis. This process corrects misclassification of data (i.e., city/town misassignment) and deletes duplicate case reports. Once these steps are finished, the data for that year are considered "complete." Due to the volume of information received by the MCR, the large number of reporting facilities, and the six-month period between diagnosis and required reporting, the most current registry data that are complete will inherently be a minimum of two years prior to the current date. At the time of this analysis, the most recent and complete data records available from the MCR include diagnoses that occurred from 1/1/1982 – 12/31/1999. Although the MCR data are currently complete through 1999, this is an on-going surveillance system that collects reports on a daily basis. Therefore, it is possible to review case reports for more recent years (i.e., 2000-present), which can provide a qualitative review of cancer patterns in a given area.

As stated above, four employees of the Holmes School were reported as having been diagnosed with cancer. Name, gender, cancer type, age at diagnosis, and length of employment at the Holmes School were reported for three of the four individuals. The fourth individual was reported as having an unknown cancer type. A name for this individual was not included in the request because the staff member who submitted the request was not in contact with this individual's family to get permission to include a name. Date of employment was also not reported for this individual.

CAP staff were able to confirm the diagnoses of three of the four individuals through the MCR. Overall, two primary site cancer diagnoses were confirmed among three individuals as having the type of cancer listed in the request. For the third individual, the type of cancer confirmed was different from that reported to the BEHA. For confidentiality reasons, information on the type of cancer that this individual was diagnosed with cannot be released. However, the risk factors and etiology for this cancer type are not thought to be related to risk factors associated with the cancer type diagnosed in the other two reported individuals.

It is important to mention that the cancer type diagnosed among two staff members of the Holmes School is the most common type of cancer diagnosed among females in Massachusetts and the United States. A female's risk for developing this cancer can change over time due to many factors, some of which are dependent upon the well-established risk factors for this cancer type. Females at an increased risk for this cancer type include those individuals who have not had children or who had their first child after the age of 30. In addition, females with a family history of this cancer are at an increased risk. Despite the vast number of studies on the causation of this cancer type, known factors are estimated to account for fewer than half of all diagnoses of this type of cancer in the general population. Researchers are continuing to examine potential risks for this type of cancer, including environmental factors.

Although some employees of the Oliver Wendell Holmes Elementary School have been diagnosed with cancer in recent years, it is important to keep in mind that cancer is a common disease. The American Cancer Society estimates that one out of every three Americans will develop some type of cancer during his or her lifetime. Over the past forty years, the rise in the number of cancer cases generally reflects the increase in the population, particularly in the older age groups. However, although most cancer types occur more frequently in older populations (i.e., age 50 and over), cancer can affect people of all ages. The most commonly diagnosed cancers for adult males include cancers of the prostate, lung and bronchus, and colon. Breast, lung and bronchus, and colon cancers are the most common cancer types diagnosed among females (ACS, 2002).

Understanding that cancer is not one disease, but a group of diseases is also very important. Research has shown that there are more than 100 different types of cancer, each with different causative (or risk) factors. In addition, cancers of a certain tissue type in one organ may have a number of causes. Cancer may also be caused by one or several factors acting over time. For example, tobacco use has been linked to lung, bladder, and pancreatic cancers. Other factors related to cancer may include lack of crude fiber in the diet, high fat consumption, alcohol abuse, and reproductive history. Heredity, or family history, is an important risk factor for several cancers. To a lesser extent, some occupational exposures, such as jobs involving contact with asbestos, have been shown to be carcinogenic (cancer causing). Environmental contaminants have also been associated with certain types of cancer (Bang, 1996; Frumkin, 1995).

According to American Cancer Society statistics, cancer is the second leading cause of death in Massachusetts and the United States. Not only will one out of three people develop cancer in their lifetime, but this tragedy will affect three out of every four families. For this reason, cancers often appear to occur in “clusters,” and it is understandable that someone may perceive that there are an unusually high number of cancer cases in their surrounding neighborhoods or towns. Upon close examination, many of these "clusters" are not unusual increases, as first thought, but are related to such factors as local population density, variations in reporting or chance fluctuations in occurrence. In other instances, the "cluster" in question includes a high concentration of individuals who possess related behaviors or risk factors for cancer. Some, however, are unusual; that is, they represent a true excess of cancer in a workplace, a community, or among a subgroup of people. A suspected cluster is more likely to be a true cancer cluster if it involves a large number of cases of one type of cancer diagnosed in a relatively short time period rather than several different types diagnosed over a long period of time (i.e., 20 years), a rare type of cancer rather than common types, and/or a large number of cases diagnosed among individuals in age groups not usually affected by that cancer. These types of clusters may warrant further public health investigation.

Based on a review of the available information, we do not believe that the cancer diagnoses among employees of the Oliver Wendell Holmes Elementary School represent an atypical pattern of cancer. That is, it does not appear that a common factor (either environmental or non-environmental) is likely related to diagnoses of cancer among these individuals.

Based upon our review of the most current cancer literature there does not appear to be an atypical pattern of cancer diagnoses among the staff. Additionally, while indoor air quality problems were noted in this report, these issues are not likely to be related to the incidence of cancer among employees at the school.

Conclusions/Recommendations

The conditions noted at the HES raise a number of indoor air quality issues. The abandonment/alteration of the original ventilation system and its components has essentially removed any means to provide mechanical ventilation for the building. Lack of environmental pollution dilution and/or removal by the ventilation system resulting from minimized airflow into the building can result in the build up and concentration of environmental pollutants in occupied area. BEHA staff attempted to identify possible environmental sources that have been suggested to play a role in the development of cancer in the staff at the HES. No evidence of direct sources associated with the disease were identified in the building.

The combination of the general building conditions, design and the operation (or lack) of HVAC equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required, consisting of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address overall indoor air quality concerns.

Short Term Recommendations

1. If mechanical ventilation systems cannot be restored to their original function, ensure abandoned exhaust and supply vents are properly sealed in classrooms and on the roof. Louvers in each fan room should be sealed to prevent basement air migration into classrooms via the abandoned ventilation system.

2. Use open windows and hallway doors to enhance airflow during warm weather. Be sure to close windows and doors at the end of the school day. To aid in the draw of fresh outdoor air in warm weather, use portable fans directing air out windows on the leeward side of the building. Fans positioned in this manner will serve to increase the draw of outdoor air across a floor without interfering with the natural, internal airflow pattern of the building. To aid cross ventilation, open hallway doors in areas with inoperable transoms.
3. Implement prudent housekeeping and work site practices to minimize exposure to spores. This may include constructing barriers, sealing off areas, and temporarily relocating furniture and supplies. To control for dusts, a high efficiency particulate air filter (HEPA) equipped vacuum cleaner is recommended. Non-porous materials (e.g., linoleum, cement, etc.) should be disinfected with an appropriate antimicrobial agent. Non-porous surfaces should also be cleaned with soap and water after disinfection.
4. Repair water damaged ceilings, windows and building materials. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
5. Seal all utility holes, wall cracks and any other possible pathways to prevent the egress of materials from the boiler room into the music room and other occupied areas.
6. Install a drainage system in the parapet to prevent water pooling and subsequent water damage that may occur because of pooling water.
7. Clean water catch basins for water coolers periodically to prevent microbial growth.

8. Clean pans used for sponges on a daily basis to prevent microbial growth.
9. Move plants away from univents in classrooms. Ensure all plants are equipped with drip pans. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary. Consider reducing the number of plants.
10. Remove plants and weeds that are growing along building foundation.
11. Clean chalkboards and trays regularly to avoid the build-up of excessive chalk dust.
12. Consider having upholstered furniture cleaned professionally on an annual basis.
13. Install ventilation in main office to prevent build up of VOCs from photocopiers.
14. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
15. Store cleaning products properly and out of reach of students.
16. Use the principles of integrated pest management (IPM) to rid this building of pest. Activities that can be used to eliminate pest infestation may include the following activities.
    a) Do not use recycled food containers. Seal recycled containers in a tight fitting lid to prevent rodent access.
    b) Remove non-food items that rodents are consuming.
    c) Stored foods in tight fitting containers.
    d) Avoid eating at workstations. In areas were food is consumed, periodic vacuuming to remove crumbs are recommended.

e) Regularly clean crumbs and other food residues from toasters, toaster ovens, microwave ovens coffee pots and other food preparation equipment;

f) Examine each room and the exterior walls of the building for means of rodent egress and seal appropriately. Holes as small as ¼" is enough space for rodents to enter an area. If doors do not seal at the bottom, install a weather strip as a barrier to rodents

g) Reduce harborages (cardboard boxes) where rodent may reside.

A copy of the IPM Guide can be obtained at the following Internet address: http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf

17. Remove soda can from drain.
18. Consider adopting the US EPA document, "Tools for Schools" as a means to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
19. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

Long Term Recommendations

1. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the restoration of the mechanical ventilation system.

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Figure 1 **Cross Ventilation in a Building Using Open Windows and Hallway Doors**

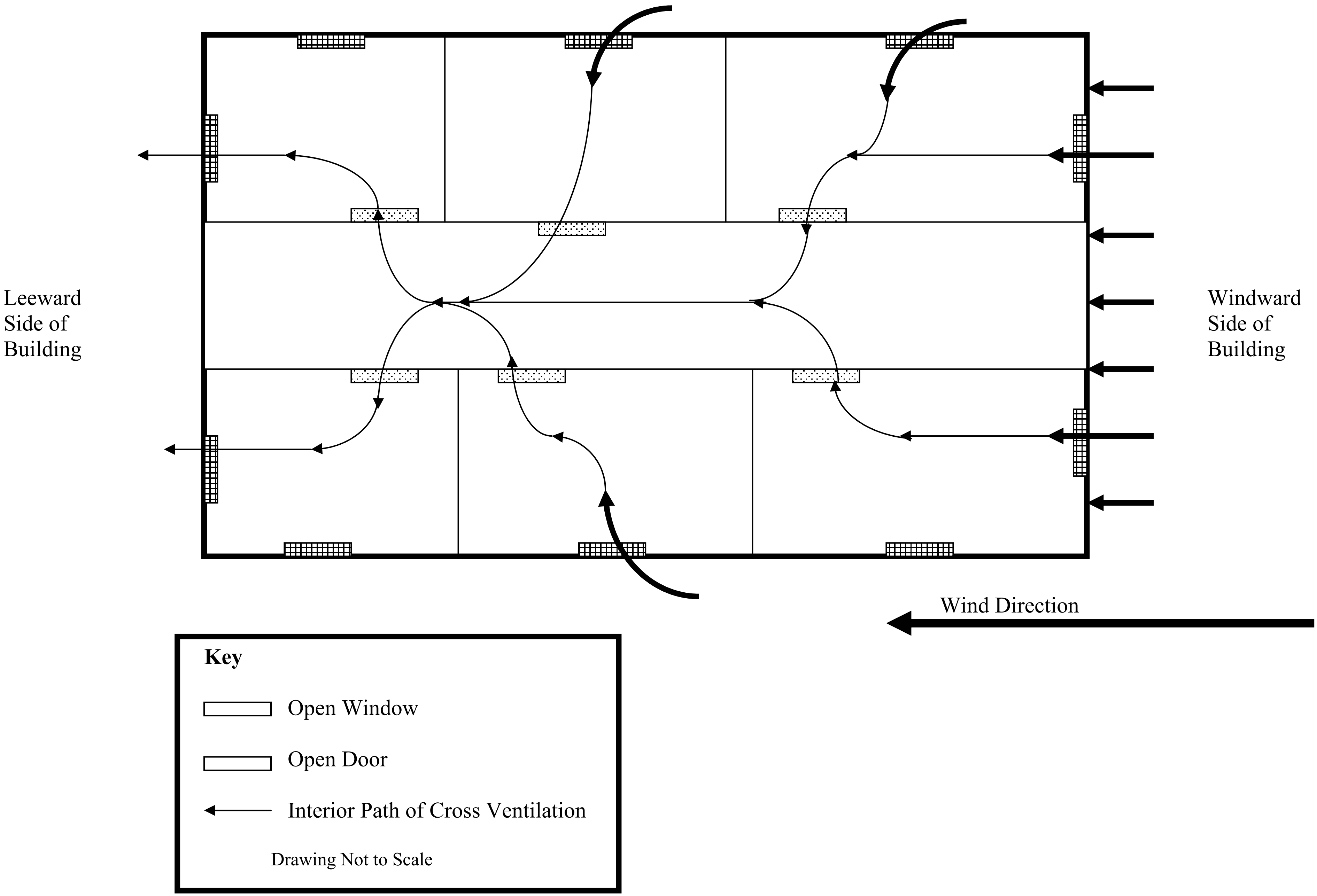
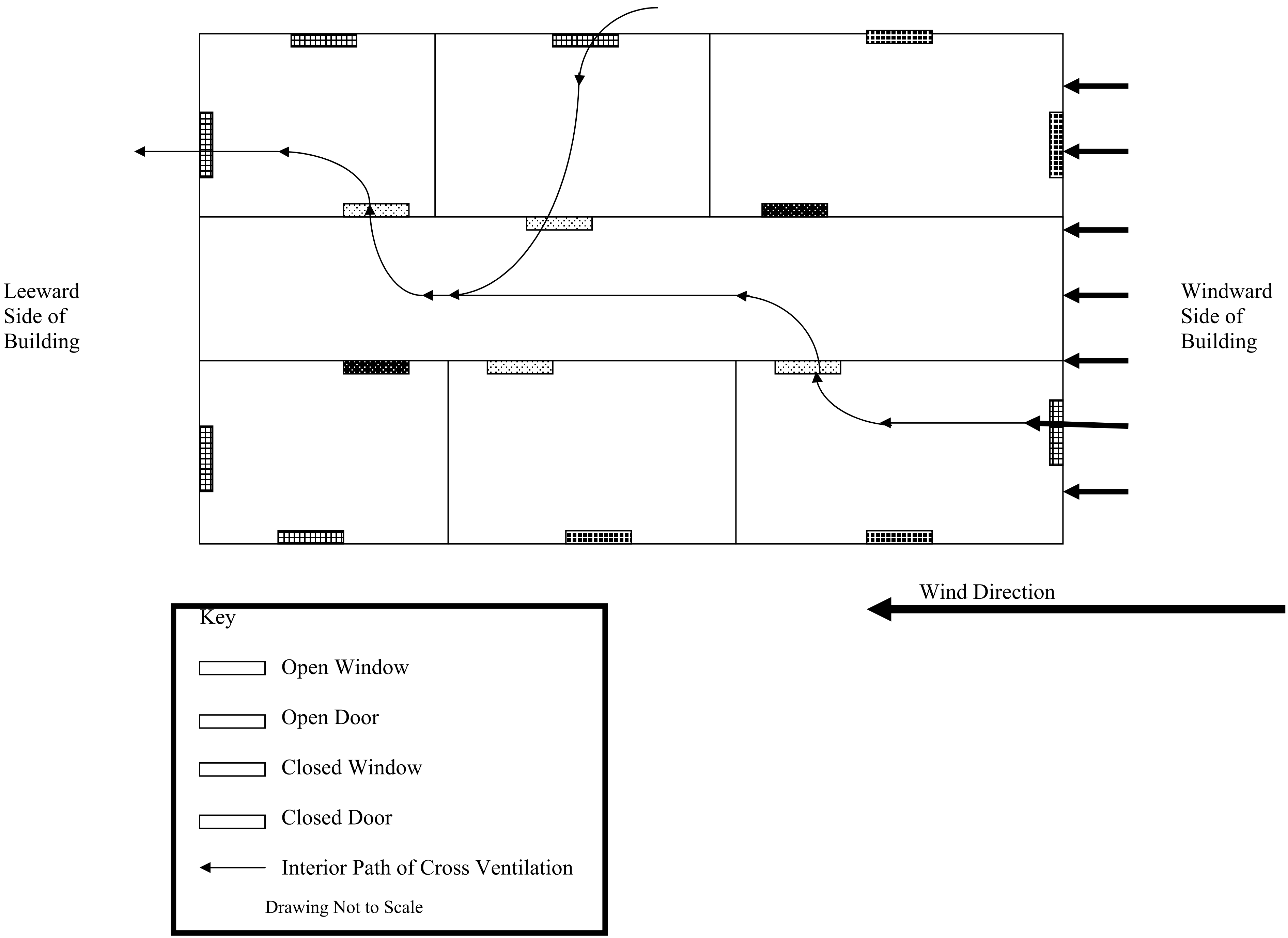


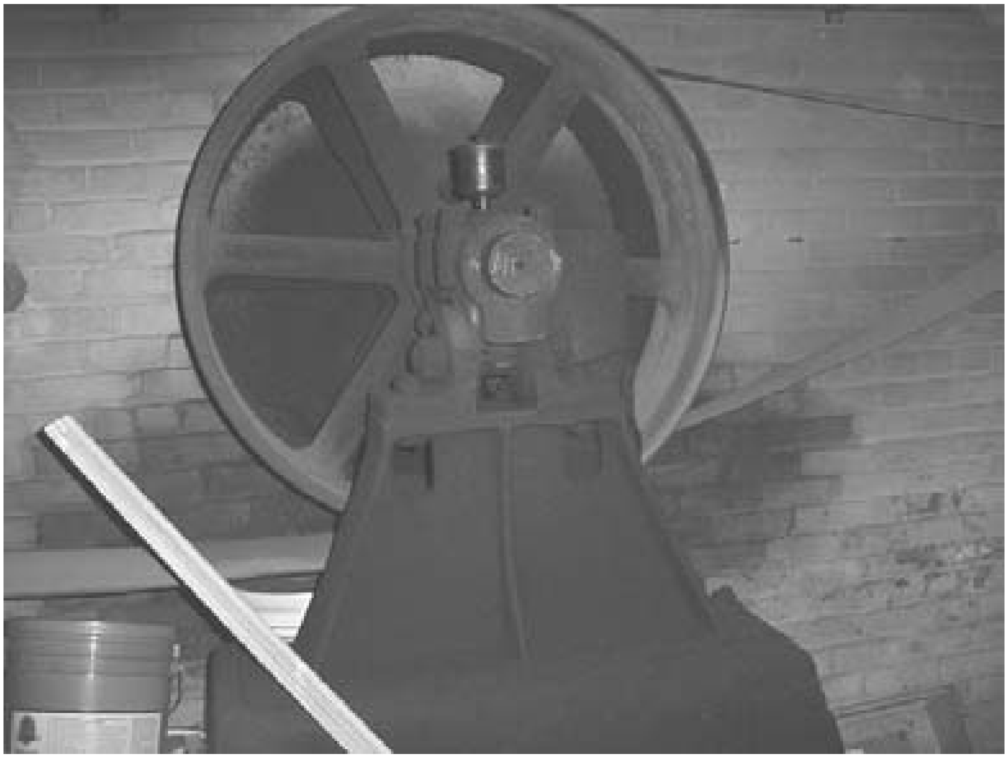
Figure 2 **Inhibition of Cross Ventilation in a Building with Several Windows and Hallway Doors Closed**



Picture 1

Ventilation System Fan

Picture 2a



Motor Flywheel That Powered Fans

Picture 2b

Broken Fan Belt Connecting Motor to Fans

Picture 3

Fresh Air Intake for Fans

Picture 4

Classroom Supply Vent

Picture 5a

Exhaust Vents Terminus on Roof

Picture 5b

Duct within the Exhaust Vents Terminus

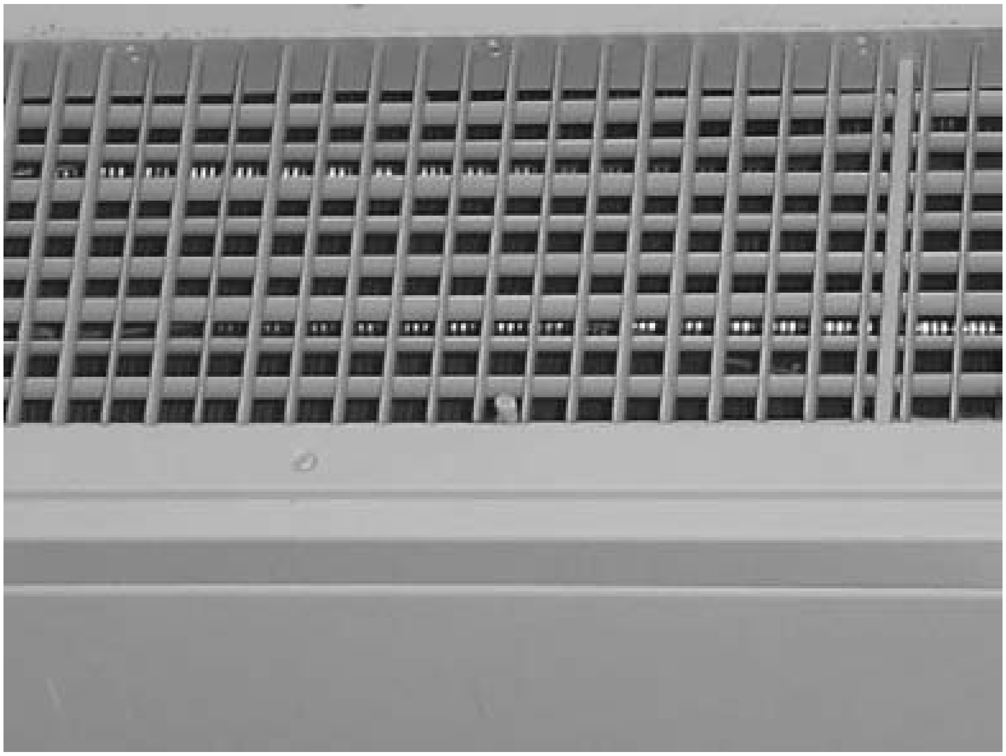
Picture 6

Classroom Exhaust Vent Blocked

Picture 7

Room 002 Univent

Picture 8



Cigarette Stub forced into Univent Air Diffuser

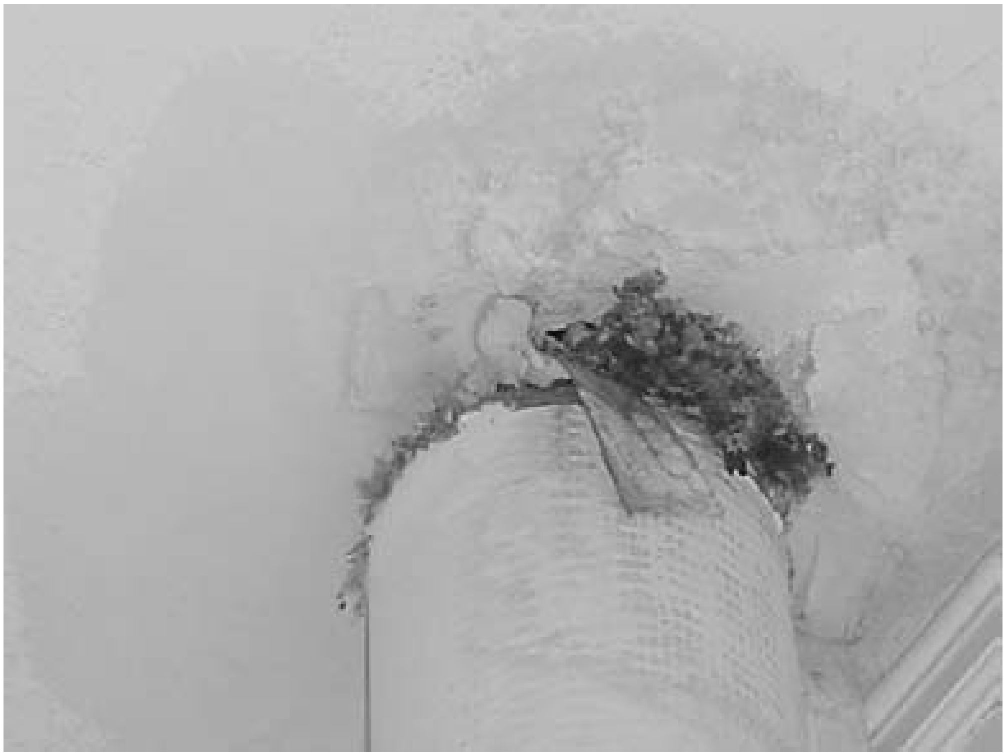
Picture 9

Water Damaged Pipe Insulation Was Noted On Pipes in the Music Room

Picture 10

Peeling Paint and Efflorescence along Exterior Brick Walls of Music Room

Picture 11



Water Damage to Ceiling and Pipe Insulation

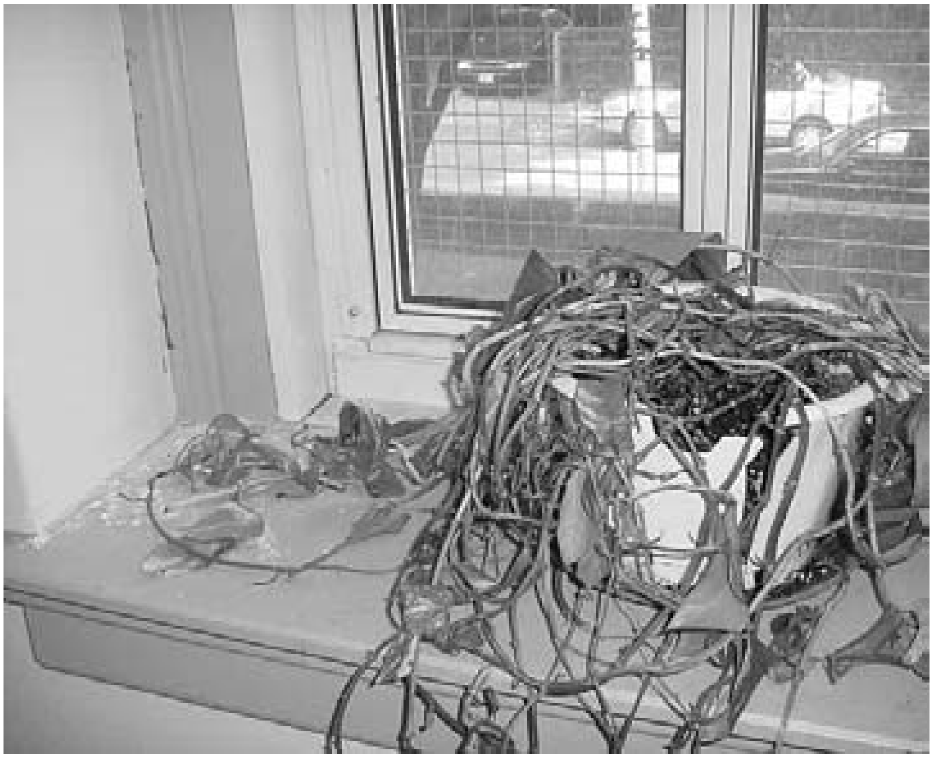
Picture 12

Standing Water in Building Parapet

Picture 13

Water Cooler with accumulated Debris in Basin

Picture 14



Plant in Hallway

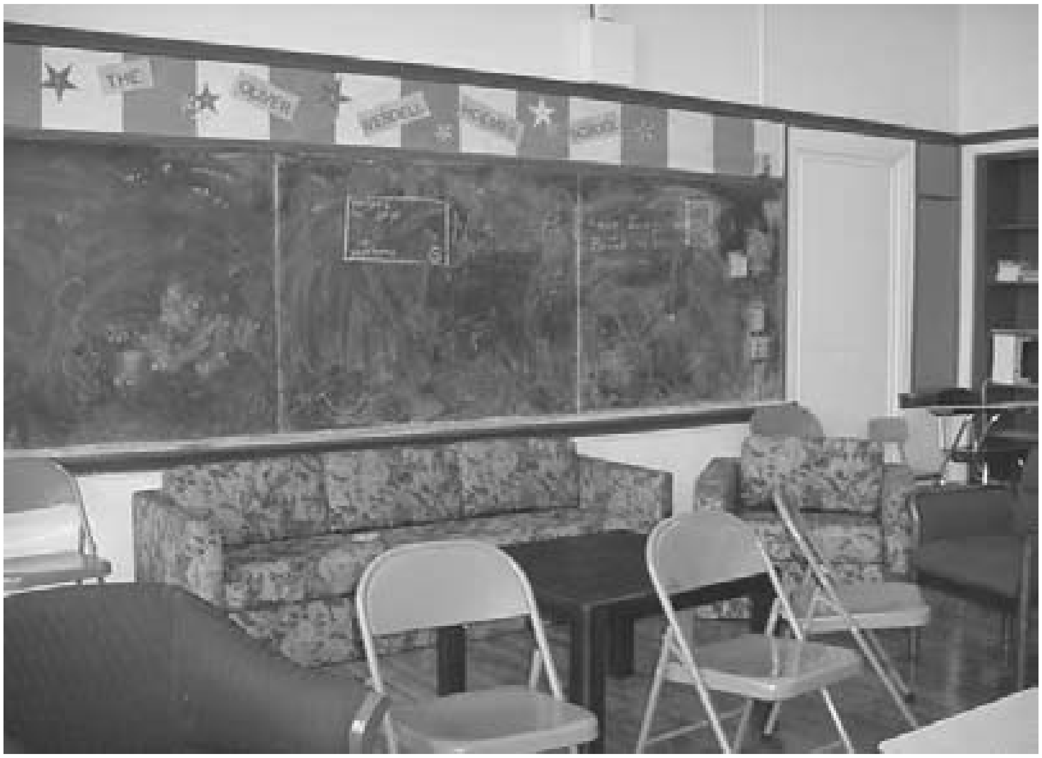
Picture 15

Ivy on Building Exterior

Picture 16

Louvers in the Fan Rooms, As Well As the Door to the Fan Rooms Are Open

Picture 17

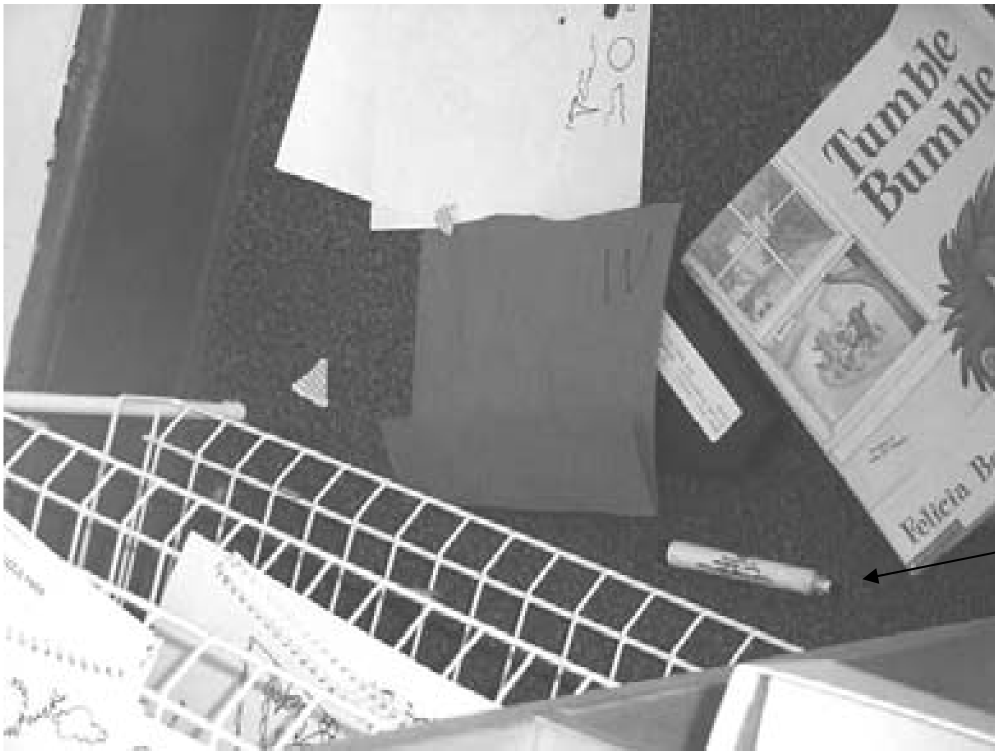


Upholstered Furniture

Picture 18

Pencil Shavings Accumulating on a Window Ledge, at the Base of Pencil Sharpener

Picture 19



Permanent marker

Uncapped Marker In Play Area

Picture 20

Tennis Balls on Chair Legs

Picture 21

Rock Salt Is Stored In Recycled Flour Sack Within One of the Fan Rooms

TABLE 1

Indoor Air Test Results –O.W. Holmes Elementary School, Dorchester, MA June 20, 2003

Location	Carbon Dioxide (*ppm)	Temp °(F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Outside (Background)	414	76	31					Ivy, plants along building, drain blocked by can, TVOC is 0
Room 305	1270	77	47	15	Y	Y	Y	Been bag blocking gravity vent, spaces floor tiles pulling up, door exterior behind wall, bookcases blocking some heat units, pencil sharpener by window, CD
Room 308	530	73	46	0	Y	Y	Y	Window open, exhaust blocked, DEM, CD, PF, sharpener on window sill, heat units partially blocked
Storage Room 308							Y	Exhaust blocked by dust pan and broom
Upper Level Walkway by Gym								Paint peeling off window, CT
Hallway by Gym								Plants on window sill and radiator
Room 303	973	76	51	14	Y	Y	Y	Exhaust/radiator blocked, clutter, DEM, PF, PM, sponges on window sill, standing water, ceiling plaster WD, pencil sharpener on window sill, upholstered chair, carpet,

*** ppm = parts per million parts of air**

CD = chalk dust DEM = dry erase materials PM = permanent marker PF = personal fan WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results –O.W. Holmes Elementary School, Dorchester, MA June 20, 2003

Location	Carbon Dioxide (*ppm)	Temp °(F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
East Wing Hall								Standing water in parapit, plants on sill by radiator
West Wing Hall								Parapit – standing water
Room 205	821	78	51	2	Y	Y	Y	CD, upholstery – curtains, pesticide trap in corner bathroom side, WD wall
Room 303	903	76	49	16	Y	Y	Y	Exhaust blocked, floor pillars, dried out soil on window sill, CD, DEM, white out
Room 204	596	76	47	0	Y	Y	Y	Book storage, WD pipe, mainframe, PM
Room 101	548	76	47	1	Y	Y	Y	Exhaust blocked, clutter, carpeting, cleaning agent under sink, CD, plants on window sill, DEM, pencil sharpener on window
Nurse's Office Outer Room	700	75	49	0	N	N	Y	Photocopier, risograph, door open, potting soil, activated carbon under sink
Hall outside Principal's Office								Plants on sill, WD to windows
Room 103	665	75	49	0	Y	Y	Y	Exhaust partially blocked, DEM, CD, upholstered furniture, damaged piping

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TABLE 1

Indoor Air Test Results –O.W. Holmes Elementary School, Dorchester, MA June 20, 2003

Location	Carbon Dioxide (*ppm)	Temp °(F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
								insulation
Room 106	581	74	45	4	Y	Y	Y	Exhaust blocked, tennis balls, CD, 4 computers, plant on sill, door open, door open between rooms, spray adhesive, DEM, 1 window open
Room 002	816	72	53	2	Y	Y	Y	CD, cleaning products on sink counter, clutter WD window sill, plants on WS, items hanging from pipes, seat cushions, pillars, DEM, door open between rooms, tennis balls on sink, space heater
Library	762	75	50	14	Y	Y	Y	Window open, items hanging from light 20 computers, platter, clutter, DEM, CD items on window sill, air deodorizer, door open
Fan Room								TVOC = 0
Band Room								TVOC = 0

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TABLE 1

Indoor Air Test Results –O.W. Holmes Elementary School, Dorchester, MA June 20, 2003

Location	Carbon Dioxide (*ppm)	Temp °(F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Room 307	838	75	54	12	Y	Y	Y	Window/door open, exhaust blocked with boxes, CD
Room 305	596	75	52	0	Y	Y	Y	
Third Floor Way								Water cooler with standing water
Room 302	621	74	48	12	Y	Y	Y	Clutter, DEM, CD, PM
Room 303	625	75	51	0	Y	Y	Y	Algae fish tank; PM, DEM, Tennis balls
Room 301	574	76	49	0	Y	Y	Y	DEM
Gym	588	74	50	0	Y	Y	Y	Window open
Room 206	885	75	52	16	Y	Y	Y	Window open, dry erase board Exhaust blocked with boxes
Room 207	1286	76	55	15	Y	Y	Y	Window open Exhaust blocked with boxes

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TABLE 1

Indoor Air Test Results –O.W. Holmes Elementary School, Dorchester, MA June 20, 2003

Location	Carbon Dioxide (*ppm)	Temp °(F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Room 202	521	74	47	1	Y	Y	Y	Window open, DEM
Boys' Rest Room							Y	Exhaust off
Room 102	707	74	51	16	Y	Y	Y	Window open, DEM
Teacher's Room	811	76	55	0	Y	N	N	2 refrigerators, soda machine, upholstered furniture
Room 103	799	76	56	0	Y	N	N	laminator
Room 105	1001	76	52	6	Y	Y	Y	
Cafeteria	984	73	52	50+	Y	Y	Y	
Band Room	596	70	58	0	Y	N	N	Hole in wall, bait trap
Room 603	808	70	62	0	Y	Y	N	Supply off, tennis balls, balloons

*** ppm = parts per million parts of air**

CD = chalk dust DEM = dry erase materials PM = permanent marker PF = personal fan WD = water damage

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Appendix C

Risk Factor Information for Selected Cancer Types

<u>Breast Cancer</u>

Breast cancer is the most frequently diagnosed cancer among women in both the United States and in Massachusetts. According to the North American Association of Central Cancer Registries, female breast cancer incidence in Massachusetts is the fifth highest among all states (Chen et al, 2000). Although during the 1980s breast cancer in the U.S. increased by about 4% per year, the incidence has leveled off to about 110.6 cases per 100,000 (ACS 2000). A similar trend occurred in Massachusetts and there was even a slight decrease in incidence (1%) between 1993 and 1997 (MCR 2000).

In the year 2003, approximately 211,300 women in the U.S. will be diagnosed with breast cancer (ACS 2003). Worldwide, female breast cancer incidence has increased, mainly among women in older age groups whose proportion of the population continues to increase as well (van Dijck, 1997). A woman's risk for developing breast cancer can change over time due to many factors, some of which are dependent upon the well-established risk factors for breast cancer. These include increased age, an early age at menarche (menstruation) and/or late age at menopause, late age at first full-term pregnancy, family history of breast cancer, and high levels of estrogen. Other risk factors that may contribute to a woman's risk include benign breast disease and lifestyle factors such as diet, body weight, lack of physical activity, consumption of alcohol, and exposure to cigarette smoke. Data on whether one's risk may be affected by exposure to environmental chemicals or radiation remains inconclusive. However, studies are continuing to investigate these factors and their relationship to breast cancer.

Family history of breast cancer does affect one's risk for developing the disease. Epidemiological studies have found that females who have a first-degree relative with premenopausal breast cancer experience a 3-fold greater risk. However, no increase in risk has been found for females with a first degree relative with postmenopausal breast cancer. If women have a first-degree relative with bilateral breast cancer (cancer in both breasts) at any age then their risk increases five-fold. Moreover, if a woman has a mother, sister or daughter with bilateral premenopausal breast cancer, their risk increases nine fold. (Broeders and Verbeek, 1997). In addition, twins have a higher risk of breast cancer compared to non-twins (Weiss et al, 1997).

A personal history of benign breast disease is also associated with development of invasive breast cancer. Chronic cystic or fibrocystic disease is the most commonly diagnosed benign breast disease. Women with cystic breast disease experience a 2-3 fold increase in risk for breast cancer (Henderson et al, 1996).

According to recent studies, approximately 10% of breast cancers can be attributed to inherited mutations in breast cancer related genes. Most of these mutations occur in the BRCA1 and BRCA2 genes. Approximately 50% to 60% of women who inherit BRCA1 or BRCA2 gene mutations will develop breast cancer by the age of 70 (ACS 2001).

Cumulative exposure of the breast tissue to estrogen and progesterone hormones may be one of the greatest contributors to risk for breast cancer (Henderson et al, 1996).

Researchers suspect that early exposures to a high level of estrogen, even during fetal development, may add to one's risk of developing breast cancer later in life. Other studies have found that factors associated with increased levels of estrogen (i.e., neonatal jaundice, severe prematurity, and being a fraternal twin) may contribute to an elevated risk of developing breast cancer (Ekbom et al, 1997). Conversely, studies have revealed that women whose mothers experienced toxemia during pregnancy (a condition associated with low levels of estrogen) had a significantly reduced risk of developing breast cancer. Use of estrogen replacement therapy is another factor associated with increased hormone levels and it has been found to confer a modest (less than two-fold) elevation in risk when used for 10-15 years or longer (Kelsey, 1993). Similarly, more recent use of oral contraceptives or use for 12 years or longer seems to confer a modest increase in risk for bilateral breast cancer in premenopausal women (Ursin et al, 1998).

Cumulative lifetime exposure to estrogen may also be increased by certain reproductive events during one's life. Women who experience menarche at an early age (before age 12) have a 20% increase in risk compared to women who experience menarche at 14 years of age or older (Broeders and Verbeek, 1997; Harris et al, 1992). Women who experience menopause at a later age (after the age of 50) have a slightly elevated risk for developing the disease (ACS 2001). Furthermore, the increased cumulative exposure from the combined effect of early menarche and late menopause has been associated with elevated risk (Lipworth, 1995). In fact, women who have been actively menstruating for 40 or more years are thought to have twice the risk of developing breast cancer than women with 30 years or less of menstrual activity (Henderson et al, 1996). Other reproductive events have also shown a linear association with risk for breast cancer (Wohlfahrt, 2001). Specifically, women who gave birth for the first time before age 18 experience one-third the risk of women who have carried their first full-term pregnancy after age 30 (Boyle et al, 1988). The protective effect of earlier first full-term pregnancy appears to result from the reduced effect of circulating hormones on breast tissue after pregnancy (Kelsey, 1993).

Diet, and particularly fat intake, is another factor suggested to increase a woman's risk for breast cancer. Currently, a hypothesis exists that the type of fat in a woman's diet may be more important than her total fat intake (ACS 1998; Wynder et al, 1997). Monounsaturated fats (olive oil and canola oil) are associated with lower risk while polyunsaturated (corn oil, tub margarine) and saturated fats (from animal sources) are linked to an elevated risk. However, when factoring in a woman's weight with her dietary intake, the effect on risk becomes less clear (ACS 1998). Many studies indicate that a heavy body weight elevates the risk for breast cancer in postmenopausal women (Kelsey, 1993), probably due to fat tissue as the principal source of estrogen after menopause (McTiernan, 1997). Therefore, regular physical activity and a reduced body weight may decrease one's exposure to the hormones believed to play an important role in increasing breast cancer risk (Thune et al, 1997).

Aside from diet, regular alcohol consumption has also been associated with increased risk for breast cancer (Swanson et al, 1996; ACS 2001). Women who consumed one alcoholic beverage per day experienced a slight increase in risk (approximately 10%) compared to non-drinkers, however those who consumed 2 to 5 drinks per day experienced a 1.5 times increased risk (Ellison et al., 2001; ACS 2001). Despite this association, the effects of alcohol on estrogen metabolism have not been fully investigated (Swanson et al, 1996).

To date, no specific environmental factor, other than ionizing radiation, has been identified as a cause of breast cancer. The role of cigarette smoking in the development of breast cancer is unclear. Some studies suggest a relationship between passive smoking and increased risk for breast cancer; however, confirming this relationship has been difficult due to the lack of consistent results from studies investigating first-hand smoke exposure (Laden and Hunter, 1998).

Studies on exposure to high doses of ionizing radiation demonstrate a strong association with breast cancer risk. These studies have been conducted in atomic bomb survivors from Japan as well as patients that have been subjected to radiotherapy in treatments for other conditions (i.e., Hodgkin's Disease, non-Hodgkin's Lymphoma, tuberculosis, post-partum mastitis, and cervical cancer) (ACS 2001). However, it has not been shown that radiation exposures experienced by the general public or people living in areas of high radiation levels, from industrial accidents or nuclear activities, are related to an increase in breast cancer risk (Laden and Hunter, 1998). Investigations of electromagnetic field exposures in relation to breast cancer have been inconclusive as well.

Occupational exposures associated with increased risk for breast cancer have not been clearly identified. Experimental data suggests that exposure to certain organic solvents and other chemicals (e.g., benzene, trichloropropane, vinyl chloride, polycyclic aromatic hydrocarbons (PAHs)) causes the formation of breast tumors in animals and thus may contribute to such tumors in humans (Goldberg and Labreche, 1996). Particularly, a significantly elevated risk for breast cancer was found for young women employed in solvent-using industries (Hansen, 1999). Although risk for premenopausal breast cancer may be elevated in studies on the occupational exposure to a combination of chemicals, including benzene and PAHs, other studies on cigarette smoke (a source of both chemicals) and breast cancer have not shown an associated risk (Petralia et al, 1999). Hence, although study findings have yielded conflicting results, evidence does exist to warrant further investigation into the associations.

Other occupational and environmental exposures have been suggested to confer an increased risk for breast cancer in women, such as exposure to polychlorinated biphenyls (PCBs), chlorinated hydrocarbon pesticides (DDT and DDE), and other endocrine-disrupting chemicals. Because these compounds affect the body's estrogen production and metabolism, they can contribute to the development and growth of breast tumors (Davis et al, 1997; Holford et al, 2000; Laden and Hunter, 1998). However, studies on this association have yielded inconsistent results and follow-up studies are ongoing to further investigate any causal relationship (Safe, 2000).

When considering a possible relationship between any exposure and the development of cancer, it is important to consider the latency period. Latency refers to the time between exposure to a causative factor and the development of the disease outcome, in this case breast cancer. It has been reported that there is an 8 to 15 year latency period for breast cancer

(Petralia 1999; Aschengrau 1998; Lewis-Michl 1996). That means that if an environmental exposure were related to breast cancer, it may take 8 to 15 years after exposure to a causative factor for breast cancer to develop.

Socioeconomic differences in breast cancer incidence may be a result of current screening participation rates. Currently, women of higher socioeconomic status (SES) have higher screening rates, which may result in more of the cases being detected in these women. However, women of higher SES may also have an increased risk for developing the disease due to different reproductive patterns (i.e., parity, age at first full-term birth, and age at menarche). Although women of lower SES show lower incidence rates of breast cancer in number, their cancers tend to be diagnosed at a later stage (Segnan, 1997). Hence, rates for their cancers may appear lower due to the lack of screening participation rather than a decreased risk for the disease. Moreover, it is likely that SES is not in itself the associated risk factor for breast cancer. Rather, SES probably represents different patterns of reproductive choices, occupational backgrounds, environmental exposures, and lifestyle factors (i.e., diet, physical activity, cultural practices) (Henderson et al, 1996).

Despite the vast number of studies on the causation of breast cancer, known factors are estimated to account for less than half of breast cancers in the general population (Madigan et al, 1995). Researchers are continuing to examine potential risks for developing breast cancer, especially environmental factors.

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